

CERTIFICATE OF TRANSLATION

I, SHUSAKU YAMAMOTO, patent attorney of Fifteenth Floor, Crystal Tower, 1-2-27 Shiromi, Chuo-ku, Osaka 540-6015, Japan HEREBY CERTIFY that I am acquainted with the English and Japanese languages and that the attached English translation is a true English translation of what it purports to be, a translation of Japanese Laid-open Utility Model Publication No. 4-101286, entitled "High-Efficiency Power Supply Circuit", laid-opened on September 1, 1992.

Additionally, I verify under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed this 11th day of June, 1998.


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Translation of Japanese Laid-Open Utility Model Publication

Laid-Open Utility Model Publication Number: 4-101286

Laid-Open Publication Date: September 1, 1992

Title of the Invention: HIGH-EFFICIENCY POWER SUPPLY
CIRCUIT

Utility Model Application Number: 3-994

Filing Date: January 17, 1991

Inventor: S. MORIOKA

Applicant: TOSHIBA CORPORATION and TOSHIBA COMPUTER
ENGINEERING, CO. LTD.

[Title of the Invention] High-efficiency power supply
circuit

[Claim]

[Claim 1] A high-efficiency power supply circuit implemented as a DC-DC converter comprising: a first switching element to be turned ON/OFF in response to an external signal; an inductor for supplying energy to a load in accordance with a state of the first switching element; a rectifying diode; and a smoothing capacitor, wherein the high-efficiency power supply circuit is characterized by further including a second switching element which is connected in parallel to the rectifying diode, and is controlled to be bidirectionally turned ON/OFF in synchronism with the first switching element, and a comparator for detecting a voltage drop by the rectifying diode and the second switching element and detecting the direction of current flowing through the inductor, thereby turning

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ON/OFF the second switching element.

[Detailed Description of the Invention]

[0001]

[Objective of the Invention]

[0002]

[Field of the Invention]

This invention relates to a high-efficiency power supply circuit such as a DC-DC converter suitably applicable to portable units like personal computers, in particular.

[0003]

[Prior Art]

In a portable unit such as a personal computer, a DC-DC converter is used as a power supply. A basic configuration of a DC-DC converter is shown in Figure 2. The DC-DC converter includes: a switching element 21, such as a bipolar transistor or an MOS transistor, which is turned ON/OFF in response to an external signal; an inductor element 22 such as a coil for storing energy therein or a choke for changing the magnitude of a voltage; a smoothing capacitor 23; and a rectifying diode 24.

[0004]

The basic operation thereof is as follows. First, when the switching element 21 is turned ON, current I_{on} flows, so that energy is supplied from the side of

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an input terminal to the side of an output terminal. On the other hand, when the switching element 21 is turned OFF, current I_{off} flows, so that the energy stored in the inductor 22 is released. At this time, a part of the energy stored in the inductor 22 is lost because of a forward voltage drop of the rectifying diode 24.

[0005]

Another configuration of a DC-DC converter which has been modified for reducing the loss caused by the diode is shown in Figure 3. Specifically, another switching element 31, the switching of which is controlled such that the switching element 31 is bidirectionally turned ON/OFF in synchronism with the switching element 21, is provided separately from the switching element 21 for the configuration shown in Figure 2. A timing relationship between these switching elements is defined such that when the switching element 21 is ON, the switching element 31 is turned OFF, and that when the switching element 21 is OFF, the switching element 31 is turned ON. This configuration utilizes a fact that a voltage drop between the source and the drain of the bidirectional switching element 31 is considerably smaller than a forward voltage drop of the diode 24.

[0006]

[Problems to be Solved by the Invention]

In the configuration shown in Figure 3, in an operation mode in which the switching element 21 is turned ON after all of the energy stored in the inductor 22 has

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completely been released (i.e., extra energy which is not consumed by the load returns to the power supply), the extra energy which is not consumed by the load is once stored as magnetic energy in the inductor 22, and then returns as electric energy to the power supply. Since the energy returns from a light load to the power supply in such a manner, a power loss is caused and the efficiency of the power supply is decreased at this time. Thus, power cannot be supplied to a largely variable load, irrespective of the state of the load. Moreover, if such a situation is to be avoided by the circuit configuration shown in Figure 3, then the capacitance of the inductor 22 adversely increases.

[0007]

This invention has been devised in view of the above-described state in the art, for the purpose of providing a high-efficiency power supply circuit which can efficiently supply power even when a load is light.

[0008]

[Structure of the Invention]

[0009]

[Means for Solving the Problems]

This invention is a DC-DC converter including: a first switching element to be turned ON/OFF in response to an external signal; an inductor for supplying energy to a load in accordance with a state of the first switching element; a rectifying diode; and a smoothing capacitor.

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The high-efficiency power supply circuit is characterized by further including a second switching element which is connected in parallel to the rectifying diode, and is controlled to be bidirectionally turned ON/OFF in synchronism with the first switching element, and a comparator for detecting a voltage drop by the rectifying diode and the second switching element and detecting the direction of current flowing through the inductor, thereby turning ON/OFF the second switching element.

[0010]

[Function]

In the above-described configuration, the direction of the current flowing through the inductor is detected by the comparator, and the turn ON/OFF of the second switching element is controlled in accordance with the output of the comparator, thereby realizing a power supply exhibiting a high efficiency even when the load is light. Thus, even when the load is light, the efficiency does not decrease and the capacitance of the inductor need not be increased.

[0011]

[Examples]

Hereinafter, an example of the present invention will be described in detail with reference to the drawings. Figure 1 is a circuit diagram showing an example of the present invention.

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[0012]

In Figure 1, 11 is a switching element, such as a bipolar transistor or an MOS transistor, which is turned ON/OFF in response to an external signal, 12 is an inductor element such as a coil for storing energy therein or a choke for changing the magnitude of a voltage, and 13 is a smoothing capacitor. 14 is a switching element which is provided separately from the switching element 11 and the switching of which is controlled such that the switching element 14 is bidirectionally turned ON/OFF in synchronism with the switching element 11. 15 is a comparator for detecting the voltage drop of the switching element 14 and detecting the direction of current flowing through the inductor 12, thereby turning ON/OFF the switching element 14 in accordance with the direction. 16 and 17 are parasitic diodes.

[0013]

Hereinafter, the operation of this exemplary power supply circuit according to the present invention will be described in detail. As shown in Figure 1, first, when the switching element 11 is turned ON, if the switching element 14 is also ON (a specific operation mode in which the switching element 14 is ON will be described later), then current I_{on} flows through the switching element 11 → the switching element 14 → GND in this order. A signal to be activated in accordance with the output of the comparator 15 (a high-level signal) is supplied to the switching element 14. However, when the current I_{on} flows through the switching element 14, a certain voltage drop is

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caused between the terminals of the switching element 14. As a result, the point denoted by a in Figure 1 has a positive (+) polarity and the point denoted by b in Figure 1 has a negative (-) polarity. Then, the output of the comparator 15 becomes low and the switching element 14 is turned OFF. After the current stops flowing through the switching element 14, the output of the comparator 15 is still low. When the switching element 14 is turned OFF, current I_{on2} begins to flow from the power supply to the load.

[0014]

Next, when the switching element 11 is turned OFF, the energy stored in the inductor 12 is released and current I_{off1} flows. At this point in time, since the switching element 14 has been turned OFF, the current flows through the parasitic diode 17 of the switching element 14. Thus, since the point a becomes (-) and the point b becomes (+), the output of the comparator 15 becomes high and the switching element 14 is turned ON. The voltage drop of the switching element 14 in this case is considerably smaller as compared with a conventional power supply circuit using a diode. Consequently, the efficiency thereof is improved. If the switching element 11 is turned ON before the energy stored in the inductor 12 has completely been released, the same operation is repeatedly performed from the start point initially described about this operation.

[0015]

Next, if the switching element 11 is not turned

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ON even after the switching element 11 has been turned OFF and the energy stored in the inductor 12 has completely been released (i.e., when the load is light), then current I_{off2} flows such that the energy stored in the capacitor 13 is transmitted through the inductor 12 to GND. In this case, since the point a becomes (+) and the point b becomes (-), a low level signal is supplied to the switching element 14, so that the switching element 14 is turned OFF instantaneously. That is to say, since this current no longer flows, an operation mode in which power returns from the load to the power supply does not exist. Consequently, even when the load is light, the efficiency of the power supply is not decreased. In actuality, it is only after the current I_{off2} starts to flow that the comparator 15 turns the switching element 14 OFF. As a result, a very small amount of current is stored in the inductor 12 before the turn OFF of the switching element 14 and power returns to the power supply via a current path I_{off3} . However, since the amount of the returning power is very small and the power to be lost in this mode is even smaller, such a delay is negligible in practical use.

[0016]

[Effect of the Invention]

As is apparent from the foregoing description, according to this invention, even when a load is light, the efficiency of a power supply is not decreased and the capacitance of an inductor need not be increased. Thus, this invention can also contribute to cost reduction.

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[Brief Description of the Drawings]

[Figure 1]

A circuit diagram showing an example of this invention.

[Figure 2]

A circuit diagram showing a conventional example.

[Figure 3]

A circuit diagram showing another conventional example.

[Description of the Reference Numerals]

11, 14 switching element

12 inductor

13 capacitor

15 comparator

16, 17 parasitic diode

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[Abstract]

[Objective] This invention relates to a high-efficiency power supply circuit such as a DC-DC converter suitably applicable to portable units like personal computers, in particular. The objective of this invention is to provide a high-efficiency power supply circuit which can efficiently supply power even when a load is light.

[Structure] The high-efficiency power supply circuit of this invention is a DC-DC converter including: a first switching element to be turned ON/OFF in response to an external signal; an inductor for supplying energy to a load in accordance with a state of the first switching element; a rectifying diode; and a smoothing capacitor. The high-efficiency power supply circuit is characterized by further including a second switching element which is connected in parallel to the rectifying diode, and is controlled to be bidirectionally turned ON/OFF in synchronism with the first switching element, and a comparator for detecting a voltage drop by the rectifying diode and the second switching element and detecting the direction of current flowing through the inductor, thereby turning ON/OFF the second switching element.

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【実用新案登録請求の範囲】

【請求項1】 外部信号によりオンオフする第1のスイッチング素子と、第1のスイッチング素子の状態に従い負荷に対してエネルギーを供給するインダクタと、整流ダイオード、平滑コンデンサで構成されるDC-DCコンバータにおいて、上記整流ダイオードと並列に接続され、第1のスイッチング素子と同期して両方向にオンオフ制御を行う第2のスイッチング素子と、上記整流ダイオードならびに第2のスイッチング素子による電圧降下を検出してインダクタに流れる電流の方向を検出して第2のスイッチング素子をオンオフするコンパレータとを

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具備することを特徴とする高効率電源回路。

【図面の簡単な説明】

【図1】 本考案の実施例を示す回路図。

【図2】 従来例を示す回路図。

【図3】 従来例を示す回路図である。

【符号の説明】

1 1、1 4…スイッチング素子

1 2 ……インダクタ

1 3 ……コンデンサ

1 5 ……コンパレータ

1 6、1 7…整流ダイオード

FIG.1

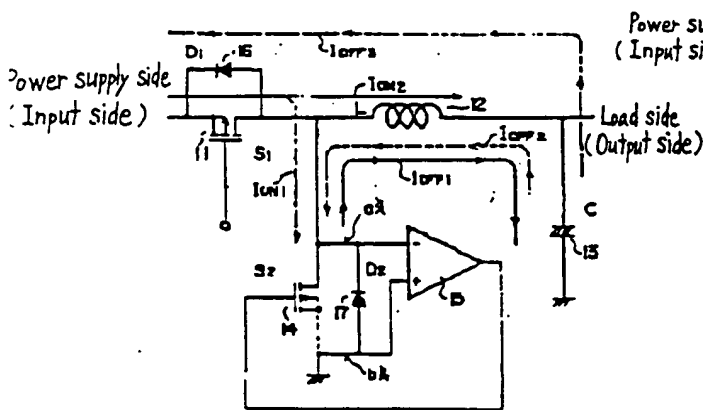


FIG.2

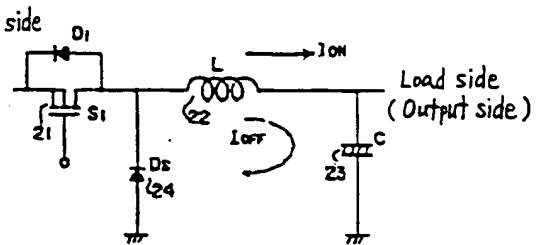
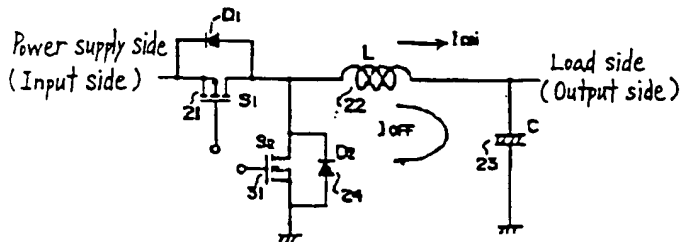


FIG.3



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(54) 【考案の名称】 高効率電源回路

(57) 【要約】

【目的】 この考案は、特にパーソナルコンピュータ等ポータブル機器に用いて好適なDC-DCコンバータ等高効率電源回路に関し、軽負荷時にも、効率よく電力供給が可能な高効率電源回路を提供することを目的とする。

【構成】 外部信号によりオンオフする第1のスイッチング素子と、第1のスイッチング素子の状態に従い負荷に対してエネルギーを供給するインダクタと、整流ダイオード、平滑コンデンサで構成されるDC-DCコンバータにおいて、上記整流ダイオードと並列に接続され、第1のスイッチング素子と同期して両方向にオンオフ制御を行う第2のスイッチング素子と、上記整流ダイオードならびに第2のスイッチング素子による電圧降下を検出してインダクタに流れる電流の方向を検出して第2のスイッチング素子をオンオフするコンパレータとを具備することを特徴とする。

【実用新案登録請求の範囲】

【請求項1】 外部信号によりオンオフする第1のスイッチング素子と、第1のスイッチング素子の状態に従い負荷に対してエネルギーを供給するインダクタと、整流ダイオード、平滑コンデンサで構成されるDC-DCコンバータにおいて、上記整流ダイオードと並列に接続され、第1のスイッチング素子と同期して両方向にオンオフ制御を行う第2のスイッチング素子と、上記整流ダイオードならびに第2のスイッチング素子による電圧降下を検出してインダクタに流れる電流の方向を検出して第2のスイッチング素子をオンオフするコンパレータとを

具備することを特徴とする高効率電源回路。

【図面の簡単な説明】

【図1】 本発明の実施例を示す回路図。

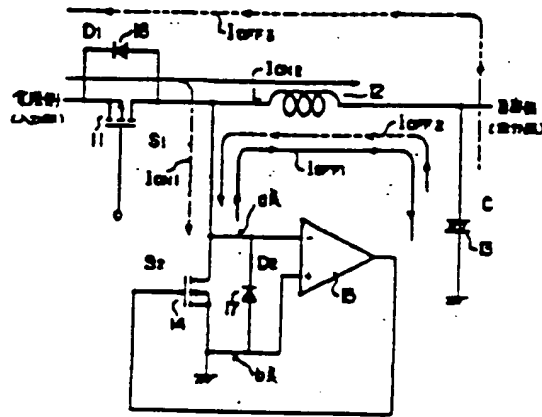
【図2】 従来例を示す回路図。

【図3】 従来例を示す回路図である。

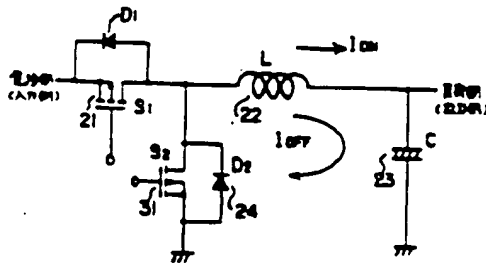
【符号の説明】

- 11、14…スイッチング素子
- 12………インダクタ
- 13………コンデンサ
- 15………コンパレータ
- 16、17…整流ダイオード

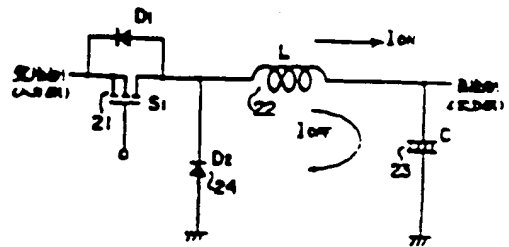
【図1】



【図3】



【図2】



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